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Christian Keuschnigg, IFF-HSG, CEPR and CESifo
Mirela Keuschnigg,
Johannes Kepler University Linz and HSG

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Department of Economics University of St. Gallen

Editor:	Prof. Jörg Baumberger University of St. Gallen Department of Economics Bodanstr. 1 CH-9000 St. Gallen Phone ++41 71 224 22 41 Fax ++41 71 224 28 85 Email joerg.baumberger@unisg.ch
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Christian Keuschnigg

Mirela Keuschnigg

Co-Author's address: Mirela Keuschnigg, PhD
Johannes Kepler University Linz and
University of St. Gallen
Hebelstrasse 10
CH-9000 St. Gallen
Tel. ++41 71 223 32 46
Email Keuschnigg@swissonline.ch

Main Author's address: Prof. Christian Keuschnigg
IFF-HSG
Varnbüelstrasse 19
CH-9000 St. Gallen
Tel. ++41 71 224 25 20
Fax ++41 71 224 26 70
Email christian.keuschngg@unisg.ch
Website www.iff.unisg.ch

Abstract

This paper investigates the dynamic consequences of demographic change and various pension reform scenarios for Austria. The analysis is based on a computable overlapping generations model with life-cycle labor supply, savings, and search unemployment. The public sector is decomposed into general government and an unfunded pension system with a tax benefit linkage. Our quantitative analysis considers several pension reform scenarios on top of the demographic transition in an aging society. We find that lowering the pension replacement rate and increasing the retirement age can have strong labor market effects. They strengthen labor supply both in terms of job search intensity, leading to lower unemployment rates, and hours worked.

Keywords

Pension reform, demographic change, unemployment

JEL Classification

C68, D58, E62, J64, H55

1 Introduction

Pension reform has important economy wide repercussions. In particular, it is expected to affect labor market performance. Depending on the extent of the tax benefit link, contributions to a PAYG system partly have tax character. The return to contributions depends on population and productivity growth and, therefore, is lower than the real interest rate in a dynamically efficient economy. Thus, contributions tend to be actuarially unfair from an individual perspective, and are partly perceived as taxes. Distorting labor taxes, in turn, restrict labor demand and are a source of unemployment.

Like in most industrial countries, aging of the population puts formidable pressure on the pension system. Given current pension rules, contribution rates would have to rise quite impressively to fund the system. Since these contributions have partly tax character, this secular rise adds to the overall labor tax burden with potentially detrimental effects on labor market performance. Cutting pensions may help to stabilize statutory contribution rates. Lower statutory rates translate into lower effective tax rates and thereby help to reduce the labor market distortion. On the other hand, pension cuts imply a lower rate of return and thereby a higher implicit tax component of *given* contribution levels. A similar argument applies to an increase in the average retirement age which is often seen as a solution to the aging problem.

Given the empirical evidence on the detrimental effects of taxes on labor supply and unemployment [see Daveri and Tabellini (2000), for example], it seems very important to carefully investigate the labor market effects of pension reform in a sufficiently detailed model of the labor market. This is then the main novel contribution of the paper which applies a detailed model of labor supply, including demographic effects, job search intensity and hours worked, to investigate potential quantitative effects of pension reform. Equilibrium unemployment results from endogenously determined labor market tightness which reflects both the job search intensity of unemployed workers and job creation by firms. With this framework at hand, we investigate the consequences of some often discussed and important measures to protect the financial viability of the pension system:

raising contribution rates, raising average retirement age and cutting pension levels.

Pension reform is the subject of a considerable literature by now (see, for example, the recent reviews by Bovenberg 2003 and Lindbeck and Persson 2003) but most of it has reduced labor market distortions to a classical labor supply decision with full employment (e.g. Homburg 1990, Breyer and Straub 1993, Fenge 1995, Brunner 1996, Lindbeck and Persson 2003), or have considered other issues in a market clearing framework such as retirement decisions, fertility, mobility of labor and political economy (e.g. Sinn 2000, Casamatta, Cremer and Pestiau 2001, Feldstein 2001, Diamond 2003). Corneo and Marquardt (2000) and Demmel and Keuschnigg (2000) studied the effects of pension reform on unemployment with union wage setting. These papers are less detailed in terms of individual labor market incentives. Further, they do not provide any quantitative effects of pension reform during a demographic transition. The existing simulation studies also do not allow to consider the effects of pension reform on unemployment (see e.g. Kotlikoff, Smetters and Walliser 2001, Börsch-Supan, Ludwig and Winter 2002, Morrow and Roeger 2004, Jensen, Lau and Poutvaara 2003 and Fehr, Jokisch and Kotlikoff 2003). Jensen et al. consider the implications of pension reform for human capital formation. Given high unemployment in Austria and even more so in other European countries, it seems rather important to investigate how pension reform affects structural unemployment.

Our tool of analysis is a numerically solved general equilibrium model with overlapping generations (OLG) of workers and retirees. It is an extension of Gertler's (1999) life cycle model where agents move stochastically into retirement, and once in retirement, face a constant risk of extinction. This extension of the basic OLG model with life-time uncertainty (pioneered by Blanchard, 1985) is not only more realistic in terms of its demographic structure and life-cycle features. It also opens up new applications with aging, labor markets and fiscal policy. Morrow and Roeger (2004) apply this framework to investigate the effects of demographic transition and pension reform in Europe. Our own contribution is to model the pension system in more detail than these authors, and to incorporate endogenous labor supply combined with search unemployment.[1] This extension is important to capture the potential labor market distortions of pension reform. Labor supply is specific to the employment state. Instead of enjoying leisure, workers may opt for more income and consumption by either working more if employed or searching for a job if unemployed. At any given date of time, increased search effort raises one's probability of finding a job and thereby allows to earn income faster than otherwise. The other aspects of the model such as private sector investment and the nature of the fiscal systems are more straightforward. The model is calibrated to Austrian data.[2]

The paper is organized as follows. The next section briefly describes the main features of the Austrian pension system and its problems with long-run sustainability in the light of projected population aging. Section 3 presents our tool of analysis. Section 4 discusses simulation results relating to our policy scenarios: aging, lower pension entitlements, and higher retirement age. A final section concludes.

2 Aging and Pension Reform in Austria

2.1 An Overview of the Pension System

Austria has a generous and expensive pay as you go (PAYG) pension system with a weak tax benefit linkage. Public pension expenditures represent about 14.5% of GDP in 2000, compared to 9.9% in 1970. They are much higher than the EU average of 10.4% of GDP (European Commission, 2001). Contributions to the pension system are not sufficient to cover total pension expenditure. The government must pay considerable transfers out of general tax revenues to finance the deficit of the pension system. The current

[1] Our model integrates search unemployment as in Pissarides (2000) with well specified intertemporal savings and investment decisions much as in the literature on unemployment and growth (see, for example, Aghion and Howitt 1994, Andolfatto 1996, Merz 1999, or Shi and Wen 1997, 1999).

[2] Keuschnigg and Keuschnigg (2003) provide a detailed model documentation including the calibration procedure. This separate technical appendix is available upon request.

deficit is 2.5% of GDP for the PAYG pension scheme. This translates into the fact that individual pension claims are only partly financed by own contributions and, thus, include a considerable lump-sum component. Reflecting this imbalance, Koman, Keuschnigg and Lüth (2002) have calculated that the unfunded future pension obligations amount to an implicit debt of approximately 200% of GDP.

The funding gap is mostly due to the fact that pension expenditures have grown quite substantially over the last decades. Over the period 1970-2000, the ratio of retirees (i.e., the number of retirees per 1000 contributors) increased by 27% while the absolute number of pensioners grew by more than 50%. Moreover, the average actual retirement age declined considerably as people opted for early retirement in much greater numbers. The statutory minimum age requirement is 60 for women and 65 for men, and 65 for civil servants (*Beamte*). However, only about 10 percent of the population between the ages of sixty and sixty-five is in the labor force. The average retirement age in the PAYG sector scheme was 58.5 for men and 56.8 for women in 2000, down from 61.9 and 61.4 in 1970. This is a consequence of early retirement and disability pensions becoming very popular over the last decades: in 1999, only 15% of new pensions were regular old-age pensions, about half the share in 1970 (IMF, 2002).

In a recent study of the Austrian pension system, Hofer and Koman (2001) argue that the sharp drop in labor force participation among the elderly is the result of strong disincentives of the Austrian pension system. The authors quantify the incentives to retire early by computing measures of social security wealth and of the implicit tax rates on continued work generated by the current system. They find the tax on continued work to become significant after the early retirement age. With these trends, labor force participation rates at older ages are now among the lowest in EU countries: between the ages of sixty and sixty-five, only about 10 percent of the population is in the labor force.

The recent fiscal consolidation and pension reforms contained measures addressing the pension system, mainly by discouraging early retirement which was made financially less attractive (see Keuschnigg et al., 2000). The required contribution period was extended and full pensions were made available only after the 60th year. To compute benefits, a maximum gross replacement rate of 80% is applied for the PAYG pension scheme. The benefits depend on the retirement age, the number of contribution periods and on the average income over of the best 18 contribution years.

2.2 Aging and Long-Run Sustainability

Like other developed countries, Austria will experience a significant aging of her population over the next 50 years. Increasing life-expectancy, combined with very low fertility rates are responsible for this trend. Eurostat (1999) forecasts an increase in life expectancy at birth from 75 (males) and 81.2 (females) in 2000 to 81 and 86, respectively, in 2050. Fertility rates are expected to increase from 1.34 to 1.5 over the same period (see Table 1). As a result, the ratio of elderly (older than 65) to people of working age (age 15-64) will more then double, i.e. it will increase from 0.23 to 0.5 in 2050, while the share of very old people (older than 79) will rise even more (IMF, 2002 and Statistik Austria).[3]

Table 1: Demographic Projections for Austria

Year	2000	2010	2020	2030	2040	2050
Old-age dependency ratio*	229	265	310	407	478	489
Overall dependency ratio**	474	478	527	634	703	716
Share of very elderly***	234	274	277	278	307	389
Life expectancy at birth (years)	78.3	79.7	81.1	82.8	83.6	84.5
Life expectancy at age 65 (years)	17.9	18.8	19.7	20.8	21.4	22.1
Migration balance (thousands)	17.272	16.358	18.808	21.296	22.694	24.005
Total fertility rate****	1.34	1.44	1.50	1.50	1.50	1.50

* 65+/(15 bis 64), per thousands; ** (0 bis 14) + 65+/(15 bis 64) per thousands; *** 80+/65+ per thousands, share of very elderly in total elderly population; **** Number of live births per female. Source: Statistik Austria

[3] As a share of the total population, the weight of those older than 64 is expected to rise from currently 15.5% to 28.5% in 2050 (EC, 2002).

As a result of population aging, all old-age related expenditures will increase, putting pressure on the finances of the welfare system and threatening the long-run fiscal sustainability. Public pension spending is expected to increase quite remarkably over the next decades, reaching 17% of GDP in 2050. Apart from demographic developments, three other factors are likely to influence the expected increase in pension spending: the share of working people in employment, the share of elderly receiving pensions, and the generosity of pension benefits. Given the expected decline in employment, government is likely to collect less revenues from taxes and social security contributions. A higher employment rate of older workers would have a double fiscal dividend: it would increase the number of contributors and decrease the number of people claiming pension benefits. Any reform that targets an improvement in women's and elderly's labor force participation as well as lowering benefits is likely to alleviate some of the spending pressure.

To sum up, future developments of pension expenditure will be determined by four driving forces: aging, employment, eligibility, and benefit rules. Decomposing overall pension expenditure and projecting each of these four parts separately, IMF (2002) arrives at an estimate of future pension spending in Austria as a share of GDP (see, in particular, Eskesen, 2002).[4] The pension reform scenarios as discussed in Austria can also be related to these four components. The various reform proposals essentially boil down to (1) making pensions less generous, resulting in a lower average replacement rate, (2) raising effective retirement age, and (3) strengthening incentives for increased labor force participation and employment to further reduce the retiree worker ratio. In our framework, aging (based on fertility and mortality assumptions) and employment are an endogenous outcome rather than exogenously projected. Furthermore, the labor market incentives of pension reform are not independently chosen but are endogenously determined by labor taxes and contribution rates as required to sustain the solvency of the pension system

[4] The Austrian authorities recently set up a Committee on Long-Term Pension Sustainability ("Kommission zur langfristigen Pensionssicherung"). The first report of the committee published in May 2000 includes similar long-run projections and emphasizes, in particular, the need to increase employment rates to stabilize the system.

and of general government.

3 A Life Cycle Economy With Pensions

We model Austria as a small open economy with an internationally fixed real interest rate and exogenous trend growth of labor productivity. Asset and physical capital accumulation reflect the intertemporal consumption and investment decisions of forward looking agents. Households save to ensure smooth consumption in the face of uneven life-cycle income patterns and, in particular, to top up public pensions and sustain their consumption level during retirement. The life-cycle is divided into a working and retirement period. During the working period, agents endogenously supply labor in terms of hours worked when employed, and time spent on job search when unemployed. Retirement terminates the flow of wage income and, instead, entitles to pension benefits. Although pensions are earnings related, the contributions to the PAYG system are partly perceived as taxes since they earn a rate of return less than the market interest rate. Since this implicit tax rate is part of the overall labor tax burden, it is particularly important to meaningfully capture labor market effects of pension reforms.[5]

The pattern of birth and mortality rates mimics the projections for demographic change. The model replicates the continued increase in the retiree worker ratio which is the source of the pension problem and dictates the much discussed changes to the system. Aging itself may have profound consequences for labor market performance since it affects the inflows and outflows of workers from the aggregate labor force. Finally, we include in much detail the separate budgets of the public sector and the pension system.

[5] Gertler (1999) introduced the life-cycle structure into the basic Blanchard (1985) model. The methodological contribution of this paper relative to the Blanchard-Gertler model is to allow for endogenous labor supply and search unemployment and to effectively compute the implicit tax rate of the pension system as part of household optimization. See the separate technical appendix by Keuschnigg and Keuschnigg (2003). See Heijdra, Keuschnigg and Kohler (2003) for some analytical results on the equilibrium unemployment rate in the reduced model without retirement.

The modeling of the pension system also includes the individually perceived tax benefit link, allowing us to calculate the implicit tax component of mandatory contributions.

3.1 Overlapping Generations

3.1.1 Demographics

The population consists of N_t^W workers and N_t^R retirees, hence total population is $N_t = N_t^W + N_t^R$. These groups are themselves composed of different age cohorts that are indexed by their date of birth, e.g. $N_{v,t}^W$ is the mass at date t of workers born at date $v \leq t$. The size of a cohort shrinks over time by $N_{v,t}^W = \omega N_{v,t-1}^W$ since only a fraction $\omega < 1$ of them remains active until next period while the other part is retired at a constant, age independent rate $1-\omega$. From an individual perspective, $1-\omega$ is the probability of a worker becoming retired next period. Starting with retirement, agents are subject to a constant, age independent mortality rate $1-\gamma$ and will thus survive to the next period only with probability γ. Hence, the mass of any given retired cohort shrinks by $N_{v,t}^R = \gamma N_{v,t-1}^R$. To keep the population groups constant, an inflow of new workers $N_{t,t}^W$ must replace the outflow into retirement and, similarly, new retirees $N_{t,t}^R$ must replace the outflow on account of death. By definition, the outflow of workers must be equal to the inflow of new retirees as in (1.c). Demographic change is therefore governed by the following system:

$$\begin{array}{rrcl}
(a) & N_t^W & = & \omega N_{t-1}^W + N_{t,t}^W, \\
(b) & N_t^R & = & \gamma N_{t-1}^R + N_{t,t}^R, \\
(c) & N_{t,t}^R & = & (1-\omega) N_{t-1}^W, \\
(d) & N_t & = & N_{t-1} + N_{t,t}^W - (1-\gamma) N_{t-1}^R.
\end{array} \quad (1)$$

In specifying the retirement and mortality rates and choosing an appropriate birth rate, the model can approximate various demographic scenarios.

3.1.2 Life-Cycle Optimization

Preferences are expressed by a CES expected utility function as proposed by Farmer (1990) and Weil (1990). A retired person chooses consumption $C_{v,t}^{R}$ to maximize expected utility subject to an intertemporal budget constraint over the rest of her life-time,

$$V_{v,t}^{R}=\left[\left(C_{v,t}^{R}\right)^{\rho}+\beta\gamma\left(V_{v,t+1}^{R}\right)^{\rho}\right]^{1/\rho},\qquad \sigma_C=1/\left(1-\rho\right), \tag{2}$$

where β is a subjective discount factor, γ is the instantaneous probability of survival, and σ_C is the constant intertemporal elasticity of substitution. Her optimal policy is to spend at each date a fraction of life-time resources on current consumption. Wealth consists of her previously accumulated financial assets plus the present value of future pension and transfer entitlements. Reflecting mortality risk, retirees have a higher marginal propensity to consume out of life-time wealth than workers.[6]

In choosing consumption, savings and labor supply today, workers anticipate how these decisions affect their welfare during retirement. At any given date, a worker retires with probability $1-\omega$ and remains active only with probability ω. Once an agent retires, her worker's salary is replaced by a lower pension payment so that her expected utility jumps from V^W to V^R. Expected utility of a worker is, thus,

$$\begin{aligned} V_{v,t}^{W} &= \left[\left(Q_{v,t}^{W}\right)^{\rho}+\beta\left(\bar{V}_{v,t+1}\right)^{\rho}\right]^{1/\rho}, \\ \bar{V}_{v,t+1} &\equiv \omega V_{v,t+1}^{W}+\left(1-\omega\right)V_{v,t+1}^{R}, \\ Q_{v,t}^{W} &\equiv C_{v,t}^{W}-\varphi\left(e_t\right)n_{v,t}^{E}-\psi\left(\xi_t\right)n_{v,t}^{U}. \end{aligned} \tag{3}$$

During their active period, agents enjoy utility from consumption $C_{v,t}^{W}$ but incur disutility from work effort e_t when employed with probability $n_{v,t}^{E}$, and effort ξ_t expended on job search when unemployment with probability $n_{v,t}^{U}$. Work and search efforts will turn out to be the same for all dynasties, i.e. $e_{v,t}=e_t$. An agent's ex ante employment probability corresponds to the household's share of employed and unemployed members, respectively, $n_{v,t}^{E}+n_{v,t}^{U}=1$.

[6] This corresponds quite well with the finding of Harrison, Lau and Williams (2002) that retired people have higher discount rates than active ones.

The utility costs of both types of effort, $\varphi(e)$ and $\psi(\xi)$, are convex and increasing functions of the respective effort levels. In assuming separable preferences, we eliminate income effects on labor supply. Therefore, an agent's instantaneous welfare is $Q^W_{v,t}$ as in (3). It is again chosen as a fraction of life-time resources which consist of previously accumulated financial assets, the present value of future transfer entitlements, the value of pension entitlements accumulated up to the present period (pension wealth), and human wealth. A worker's human wealth is the present value of expected wage related income consisting of an average of wages net of (implicit) taxes and unemployment benefits. Human wealth can also be expressed as the average of the asset values V^E and V^U attached to the states of (un-)employment, $H^W_{v,t} = V^E_t n^E_{v,t} + V^U_t n^U_{v,t}$.

3.1.3 Aggregate Household Behavior

We state here only the macroeconomic magnitudes which obtain by summing over all age groups. Aggregate consumption, for example, is defined by

$$C^W_t = \sum_{v=t}^{-\infty} C^W_{v,t} N^W_{v,t}, \qquad C^R_t = \sum_{v=t}^{-\infty} N^R_{v,t} C^R_{v,t}. \tag{4}$$

Workers are either employed or unemployed, giving $N^W_t = N^E_t + N^U_t$ in the aggregate. Due to job separation at an exogenous rate s, the number of employed declines by sN^E_t, leaving only a fraction $1-s$ in employment. On the other hand, successful job search of the unemployed raises employment. Given that a unit of search effort locates a job with probability f_t, an agent raises her employment prospects (probability $\xi_t f_t$) by supplying search effort ξ_t. Therefore, $\xi_t f_t N^U_t$ and sN^E_t reflect the inflow and outflow from employment. Labor market flows are as in Pissarides (2000) but include demographic components as well. Employment and unemployment shrink by a factor ω on account of retirement. On the other hand, the workforce is expanded by new labor market entrants $N^W_{t+1,t+1}$. They start life being unemployed since they must first search for a job before obtaining employment. Aggregate labor market flows are thus

$$\begin{aligned} N^E_{t+1} &= \omega\left[\xi_t f_t N^U_t + (1-s) N^E_t\right], \\ N^U_{t+1} &= \omega\left[sN^E_t + (1-\xi_t f_t) N^U_t\right] + N^W_{t+1,t+1}. \end{aligned} \tag{5}$$

A worker household receives an average $\bar{y}$ over net wages of employed members, $\left(1-t^W-t^{SS}\right) weN^E$, and unemployment benefits of the unemployed, zN^U. Wages w are subject to a tax at rate t^W and to social security contributions t^{SS}. Subtracting the utility cost of effort yields an effort adjusted income $\bar{w}^D$

$$\bar{y}_t = \left(1-t^W-t^{SS}\right) w_t e_t N_t^E + z_t N_t^U, \quad \bar{w}_t^D = \bar{y}_t - \varphi\left(e_t\right) N_t^E - \psi\left(\xi_t\right) N_t^U. \qquad (6)$$

If employed, a worker can raise her income in supplying increased work effort e, although at a higher effort cost. An unemployed agent may search more intensively for a job, again at the expense of disutility, and thereby raise her prospects of finding employment. Therefore, the values attached to employment and unemployment states are

$$\begin{aligned} RV_t^E &= \left(1-t^W-\hat{t}^{SS}\right) w_t e_t - \varphi\left(e_t\right) + \left[\left(1-s\right) V_{t+1}^E + sV_{t+1}^U\right] \omega/\Omega, \\ RV_t^U &= w_t^R + V_{t+1}^U \omega/\Omega, \qquad w_t^R \equiv z_t - \psi\left(\xi_t\right) + \xi_t f_t \left(V_{t+1}^E - V_{t+1}^U\right) \omega/\Omega, \end{aligned} \qquad (7)$$

where $\hat{t}^{SS}$ is the effective as opposed to the statutory rate t^{SS}, and $R = 1+r$ is the interest factor. The factor $\Omega > 1$ reflects the individual valuation of the retirement risk and leads to an increased discount rate of workers. The shadow price of employment V^E reflects current wages less disutility of effort plus the expected value of next period where the worker, if not retired, is still employed with probability $1-s$ but is separated from the job with probability s, giving a lower value V^U. The value of unemployment corresponds to future reservation wages w_t^R which consist of unemployment benefits minus search effort cost plus the expected gains from finding (with probability $\xi_t f_t$) employment.

The presence of a tax benefit link implies $\hat{t}^{SS} < t^{SS}$. Intuitively, an agent anticipates that earning higher wage income today adds to her stock of pension claims and raises the pension in retirement. This extra benefit corresponds to the part $t^{SS} - \hat{t}^{SS}$ of her contribution payment. Only the part $\hat{t}^{SS}$ is considered a tax without any corresponding benefit. This implicit tax reflects the fact that contributions are forced retirement savings that earn a lower rate of return than savings invested at the market rate of interest. Naturally, the worker's optimality conditions for work and search effort depend on the implicit rather than the statutory tax rate,

$$\varphi'(e_t) = \left(1 - t^W - \hat{t}^{SS}\right) w_t, \qquad \psi'(\xi_t) = f_t \cdot \left(V_{t+1}^E - V_{t+1}^U\right) \frac{\omega}{\Omega}. \tag{8}$$

The marginal cost of work effort, as measured in units of consumption, equals the marginal return in terms of extra wage income net of taxes. Income effects are absent due to preferences being separable in consumption and effort. In supplying ξ_t units of labor market search, the agent expects to obtain a job offer with probability $\xi_t f_t$. The expected marginal return is the increase f_t of the probability of finding a job times the expected present value of the differential future wage income. Hence, the search cost ψ' is balanced with the expected gains from finding a job.

Finally, given consumption and labor supply of workers and retirees, aggregate assets accumulate according to

$$\begin{aligned} A_{t+1}^W &= \omega\left(R_t A_t^W + \bar{w}_t^D + z_t^T N_t^W - Q_t^W\right), \\ A_{t+1}^R &= R_t A_t^R + (1-t^P)E_t + z_t^T N_t^R - C_t^R \\ &+ (1-\omega)\left(R_t A_t^W + \bar{w}_t^D + z_t^T N_t^W - Q_t^W\right), \\ A_{t+1} &= R_t A_t + \bar{y}_t + z_t^T N_t + \left(1-t^P\right) E_t - C_t, \end{aligned} \tag{9}$$

where z^T represents a lump-sum transfer and E are social security benefits, taxed at a rate t^P. Assets of retirees include net savings of the old plus the assets of new retirees who have been workers in the preperiod. The last equation uses $C_t \equiv C_t^W + C_t^R$ and $A_t \equiv A_t^W + A_t^R$ and adds up across workers and retirees.

3.2 Production Sector

Firms invest, accumulate capital and hire labor on a search labor market.[7] Some workers retire and leave for other reasons of job separation which occurs at an exogenous rate

[7] To avoid complicated notation, we describe the most important transmission channels. The actual simulation model as documented in Keuschnigg and Keuschnigg (2003) also includes other details such as exogenous trend growth of labor productivity as well as adjustment costs $J(I,K)$. The total investment cost consists of market spending and internal adjustment costs, $I+J$.

s. The firm must thus continuously replace part of its workforce by hiring new workers. When posting vacancies, it is able to fill only part of them due to matching frictions. The firm's capital K and employment N^E thus follow

$$\begin{aligned} (a) \quad K_{t+1} &= I_t + (1-\delta) K_t, \\ (b) \quad N^E_{t+1} &= \omega \left[q_t v_t + (1-s) N^E_t \right], \end{aligned} \tag{10}$$

where I is gross investment, δ the rate of depreciation, v the number of job vacancies and q the hiring probability, or the fraction of vacancies that are successfully filled. The firm produces with a linearly homogeneous technology

$$Y_t = F\left(K_t, L^D_t\right), \qquad L^D_t = L_t - \kappa v_t, \qquad L_t = e_t N^E_t. \tag{11}$$

Each worker supplies e hours of labor such that effective employment is L. The firm allocates a part L^D of its manpower to production activities and must divert the rest κv to recruitment of new workers. It thereby incurs search costs in terms of forgone output.

Investors value the firm because of its stream of dividends. After financing investment with retained earnings, the firm is able to pay dividends χ net of profit taxes at rate t^K,

$$\chi_t = \left(1 - t^K\right)\left(Y_t - w_t L_t\right) - \left(1 - t^K z^I\right) I_t. \tag{12}$$

A share z^I of investment spending is tax deductible. The investment and hiring policy generates dividends and capital gains, yielding a total return equal to $rV_t = \chi_t + V_{t+1} - V_t$. Taking as given the labor supply e per worker, firms accumulate employment and equipment to maximize shareholder value. We derive the optimality conditions

$$\begin{aligned} (a) \quad I: \quad \lambda^K_{t+1} &= 1 - t^K z^I, \\ (b) \quad v: \quad \lambda^N_{t+1} \omega q_t &= \left(1 - t^K\right) \kappa F_L. \end{aligned} \tag{13}$$

The shadow prices $\lambda^K = \partial V / \partial K$ and $\lambda^N = \partial V / \partial N$ stand for the contribution of an extra unit of capital or another job to the present value of future dividends. We find

$$\begin{aligned} (a) \quad R\lambda^K_t &= \left(1 - t^K\right) F_K + (1-\delta) \lambda^K_{t+1}, \\ (b) \quad R\lambda^N_t &= \left(1 - t^K\right)\left(F_L - w_t\right) e_t + (1-s) \omega \lambda^N_{t+1}. \end{aligned} \tag{14}$$

According to (13), investment is optimal if marginal investment cost, i.e. the net acquisition price $1 - t^K z^I$ of capital goods, just matches the marginal benefit equal to the shadow price λ_{t+1}^K. Similarly, recruitment is optimal if marginal cost in terms of foregone net revenues $\left(1 - t^K\right) \kappa F_L$ is equal to the expected gains from search equal to the probability ωq_t of successful hiring times the shadow price of employment. We obtain from (13-14) a particularly simple condition for optimal capital accumulation in the long-run, $F_K = (r + \delta) \left(1 - t^K z^I\right) / \left(1 - t^K\right)$. In a small open economy, the capital labor ratio is entirely determined by the world interest rate and the system of capital income taxation.

3.3 Wages, Matching, and Unemployment

When an unemployed person and a firm with a vacancy meet, a job surplus is to be divided among them. Filled jobs have higher value than vacancies from the firm's perspective and an employed worker is valued higher than an unemployed worker from the household's view, i.e. $V_t^E - V_t^U > 0$. The mutual gains from employment at a given wage are reflected in the asset price equations (7) and (14.b). Taking ϕ as the worker's bargaining power, the division of the surplus of a particular worker-firm pair is determined by Nash wage bargaining: $w_t^i = \arg\max \left(V_t^{E,i} - V_t^U\right)^{\phi} \left(\lambda_t^{N,i}\right)^{1-\phi}$. Bargaining yields a wage rate, per unit of effort supplied, that is a weighted average of the worker's contribution to the firm's profits, i.e. the marginal product of labor F_L, and the worker's reservation wage w^R. The reservation wage in (7) importantly depends on the unemployment benefit, corrected for search effort costs and augmented by the expected capital gain of finding employment elsewhere. The influence of taxes on wage formation largely depends on whether unemployment benefits are indexed to net wages or not. With full indexation, wages are proportional to the marginal product of labor and are rather flexible. Indexation thus tends to eliminate the effects of taxes on equilibrium unemployment. If indexation is absent and unemployment benefits are kept constant in real terms, the worker's outside option is no longer reduced when the wage tax is increased. Consequently, the tax is shifted to employers and raises the gross wage. This tax shifting reduces the returns to job creation and results in a higher equilibrium unemployment rate. In our simulations below, we assume partial indexation leading to an intermediate tax shifting.

By definition, employment of households must be equal to employment in firms, see (5) and (10). With large numbers, the individual probability $\xi_t f_t$ to locate a job is equal to the fraction of all job seekers that find employment. By the same reason, the probability q_t is the fraction of job vacancies that are successfully filled in equilibrium. Employment in the household and production sectors evolves identically only if inflows into employment are the same for households and firms, $\xi_t f_t \cdot N_t^U = m_t = q_t \cdot v_t$. Given a standard linear homogeneous matching technology $m\left(\xi N^U, v\right)$, the ratio $\theta \equiv v/\left(\xi N^U\right)$ of vacancies over effective job seekers determines the transition rates $q(\theta)$ and $f(\theta) = \theta q(\theta)$ where $f'(\theta) > 0 > q'(\theta)$. A higher ratio θ indicates a tighter labor market and thus reduces the prospects of firms to hire workers but raises the chances of unemployed to find a job.

Finally, we derive the Beveridge curve. If we assume demographic stationarity, the entry of new workers just replaces the outflow due to retirement, $N_{t+1,t+1}^W = (1-\omega) N^W$. Using this and dividing (5) by N^W yields $n_{t+1}^U = 1 - \omega + s\omega + \omega \left[1 - s - \xi_t f(\theta_t)\right] n_t^U$. In stationary labor market equilibrium, the unemployment rate is, thus,

$$n^U = \frac{1 - \omega + s\omega}{1 - (1 - s - \xi f(\theta))\,\omega}. \tag{15}$$

Unemployment falls with increased incentives for job search (higher ξ) or with increased labor market tightness on account of higher returns to job creation (higher θ).[8]

3.4 Public Sector and Current Account

The budget constraint of the PAYG pension system is

$$t^{SS} \cdot w_t e_t N_t^E + T_t^P = E_t. \tag{16}$$

[8] If there were no demographic exit rate ($\omega = 1$) and search intensity were constant ($\xi = 1$), equation (15) would reduce to the standard case of $n^U = s/(s+f)$ as in Pissarides (2000, p. 18).

The left hand side reports revenues from contributions plus government subsidies T^P to the pension system. These transfers are financed out of general tax revenue to cover potential deficits of the system. The right-hand side represents *aggregate* pension benefits of all retirees of different age cohorts. On an individual level, pensions are linked to past wages via an individually known replacement rate r^P. Supplying more work today raises wages and thereby boosts pension income during retirement. For this reason, pension contributions are only partly perceived as a tax, $\hat{t}^{SS} < t^{SS}$.

The government collects taxes T on wage, pension income and profit, and spends on public consumption C^G, unemployment benefits zN^U, interest rD^G on public debt, transfers to households $z^T N$ (other than pensions), and on transfers T^P to the pension system. As part of the policy scenario, public debt is kept constant in per capita terms. The government finances must satisfy the budget constraint

$$\begin{aligned} D^G_{t+1} &= R_t D^G_t + \left(C^G_t + z^T_t N_t + z_t N^U_t + T^P_t - T_t\right), \\ T_t &= t^W w_t e_t N^E_t + t^P E_t + t^K \left(Y_t - w_t L_t - z^I I_t\right). \end{aligned} \tag{17}$$

The current account reflects domestic savings and investment. Agents may invest savings in three perfectly substitutable assets that must yield identical rates of return in equilibrium if arbitrage is to be excluded. Private financial wealth is, thus, $A = V + D^G + D^F$, where V and D^F stand for the value of equity and net foreign assets, and D^G is government debt. The current account is $D^F_{t+1} = R_t D^F_t + \left(Y_t - I_t - C_t - C^G_t\right)$.

4 Quantitative Effects of Pension Reform

4.1 The Status Quo

Tables 2 and 3 characterize the current state of the Austrian economy prior to aging and pension reform. The first table shows key structural parameters, the second one describes the parameters of the pension system in the model. Note that the model is implemented quarterly to capture the fast labor market dynamics. While the quarterly interest rate is 1.2%, the annual rate is $(1+r)^4 - 1 \approx 4.9\%$, i.e. roughly four times as high. The behavioral parameters are largely standard in the CGE and RBC literature and within the range of empirical estimates. Average unemployment duration is only 1.3 quarters, vacancies are filled already after 1.4 quarters, and average tenure on the job is 24.2 quarters or about six years. We use a Cobb Douglas production technology. GDP shares of demand components and factor cost shares reflect Austrian data.

Table 2: Structural Parameters

real interest rate*	r	0.012
depreciation rate*	δ	0.026
intertemp.el.of subst.	σ_C	0.400
relative m.p.c.**	ϵ	1.800
labor supply elasticity	σ_L	0.400
search elasticity	σ_S	0.400
job duration*	$1/s$	24.207
unempl.duration*	$1/\xi f$	1.290
vacancy duration*	$1/q$	1.400
unemployment rate	u	0.058
repl.rate unempl.ben.	b	0.500

*) Per quarter/in quarters. **) marginal propensity to consume retirees/workers. $\sigma_L = \phi'/(e\phi'')$, $\sigma_S = \psi'/(\xi\psi'')$.

The demographic parameters determine a steady state prior to simulating the aging scenario. Starting with age 20, agents are assumed to work on average until age 59.2, the average retirement age in Austria prior to reform. The remaining life-expectancy covers another 17.8 years, or 71.2 quarters, so that life-expectancy is 77 years prior to the aging scenario. The stationary retiree worker ratio therefore amounts to 45.4 percent. The other parameters of the pension system are discussed in section 2, except that the implicit tax rate is endogenously computed in the calibrated initial steady state. In the model simulations below, the wage tax rate t^W is endogenously adjusted to satisfy the government budget constraint while all other policy parameters are exogenously specified. Further, the required contribution rate t^{SS}, implying an implicit tax rate $\hat{t}^{SS}$, is computed so that the pension system breaks even for a given size of government transfers T^P.

Table 3: Parameters of Pension System

expected working period*	$(1-\omega)^{-1}$	156.800
expected retirement period*	$(1-\gamma)^{-1}$	71.200
retirees-workers ratio	N^R/N^W	0.454
replacement rate	r^P	0.781
pension tax rate	t^P	0.142
social security tax rate	t^{SS}	0.205
implicit s.s. tax rate	$\hat{t}^{SS}$	0.037
transfer (percent of GDP)	T^P	2.500

*) Per quarter/in quarters. **) marginal propensity to consume of retirees relative to workers.

4.2 Policy Scenarios

We now apply our model to simulate the economic consequences of aging and to assess the long-run effects of some measures to reform the Austrian pension system. Our analysis is in two steps and first addresses aging of the population. Then we sequentially consider several policy initiatives for pension reform. The columns of Table 4 follow this sequence.

- **Aging:** Column LIFE in Table 4 raises life expectancy by 4.2 years so that the expected life-span is 81.2 instead of 77 years. At the same time, the inflow of new generations is adjusted such that overall population size remains constant. Given that the average retirement age is not changed, life-time extension raises the retiree worker ratio substantially from .45 to .55. Column AGE additionally allows for an increase of the overall population by 6% which results from a positive immigration balance and increased fertility.

- **Lower replacement rate:** The replacement rate calculates pensions as a fraction of acquired pension points that reflect average past wage earnings. The scenario of column REPL cuts down the replacement rate from 0.78 to 0.7 and thereby makes pensions much less generous.

- **Raising retirement age:** Aging results in an increased number of retirees per active worker and thereby makes the pension system unsustainable in its current form. Increasing the retirement age reverses the increase in the dependency ratio and is an obvious strategy to restore the viability of the system. Column RET of Table 4 reports the effects of raising the average retirement age by three years (12 quarters) which is complemented by a reduction of the length of the retirement period by three years as well.

Table 4 computes these scenarios in sequential and cumulative form. Columns LIFE and AGE compare with the initial steady state prior to demographic change where AGE includes both shocks simultaneously, i.e. a larger population and a longer life-span. The last four columns start from the AGE scenario and compare the effects of various shocks relative to this (non-stationary) baseline. The measures must be understood cumulatively so that the last column reports the percentage changes relative to the AGE baseline when all reform measures are implemented together.

4.3 Long-run Effects

4.3.1 Aging

We first investigate the effects of increasing life expectancy. Column LIFE in Table 4 reports the long-run results. As the average retirement age is held constant, the retiree worker ratio increases substantially from .45 to .55. With overall population size fixed, aging reduces the workforce and raises the number of pensioners. These demographic changes have profound effects on the public sector. Apart from pensions which are earnings related, other government expenditure is kept constant per capita of the overall population. With a rather dramatically shrinking workforce (see the reduction in employment), the wage tax base contracts and thereby necessitates a remarkable increase in the tax rate by 15 percentage points to fund government spending. The social security contribution must increase as well, raising the implicit tax by 3 percentage point which further adds to the labor tax distortion. Obviously, a tax increase of this size constitutes a strong disincentive to work, see (8). When employed, agents work fewer hours so that labor supply e per worker shrinks by more than 10 percent. The increase in the market wage is not very pronounced, however, so that labor supply decisions are dominated by the change in the wage tax. Given the large labor supply reduction and the almost constant market wage, wage income declines. Workers thus accumulate fewer pension points. Given a fixed replacement rate under existing benefit rules, the decline in wage income also translates into lower pensions. Per capita pensions decline by 11.8% and thereby limit the increase in the statutory contribution rate to 4.5 percentage points. The implicit social security tax rate increases along with it from 3.7 to 7.1%.

Why is the wage increase so small? In a small open economy, real interest is internationally fixed which prevents any long-run effect on the capital labor ratio and on labor productivity as is explained at the end of subsection 3.2. This tends to keep the wage rate constant. With wage bargaining, wages also depend on the worker's reservation wage which is largely determined by unemployment benefits. Since benefits are, by assumption, only partially indexed, they fall by less than the net of tax wage.[9] In weakening the worker's outside option, the reduction in unemployment benefits translates into lower wages. On the other hand, bargaining tends to shift taxes to employers as long as benefits are only partially indexed, see the discussion in section 3.3, and thereby tends to raise wages. The net effect is a small increase in the equilibrium wage.

[9] We compute real unemployment benefits by $z = 0.5 \times b \times \left(1 - t^W - t^{SS}\right) w + 0.5 \times z^0$, where z^0 is the initial benefit level prior to the shock.

At first sight, it seems rather surprising that aging impairs search effort so much more than hours worked. Search intensity declines by more than 18%! To understand incentives for job search, one compares in (8) the marginal cost of an extra search unit with the marginal benefit. The return to search is equal to the probability that one unit of search locates a job, times the capital gain derived from trading in the unemployed status for a job. The capital gain, $V^E - V^U$, equals the present value of the differential future wage income over the value of unemployment benefits, both corrected for work and search effort respectively.[10] Both fewer working hours and much higher taxes accumulate to substantially reduce the net of tax wage income derived from accepting a job. The opportunity cost of accepting employment also declines but considerably less so since unemployment benefits are, by assumption, only partially indexed to net wages and are partly tied to the initial benefit level prior to the shock. Therefore, taxes together with the unemployment benefit rule clearly impairs the returns to search.

Further, because higher taxes reduce hours worked, they also cut into the firm's job rent as given in (14b). The value λ^N of a filled job and thus the return to job creation in (13b) declines while the opportunity cost of recruitment, the lost output when part of the work force must be diverted from production to job search, remains constant. Obviously then, firms cut back on hiring and open fewer vacancies. Labor market tightness θ relaxes (from 1.08 to 0.84 in Table 4) which raises the probability q of firms to successfully fill a vacancy until the returns and costs of recruitment are equal again. Unemployed workers, however, will find it much more difficult to locate a job opportunity. Both the negative capital gains and the lower matching probability reinforce each other to seriously impair the returns to job search in (8). Consequently, aging leads to a much larger reduction in search effort than in hours worked when employed. Lower labor market tightness and weaker search effort both reduce the outflow from unemployment by eroding the transition rate $\xi f(\theta)$. By (15), the unemployment rate picks up, and according to Table 4, it increases quite remarkably by two percentage points, from 5.8 to 7.9%.

[10] The reader may verify this by taking the difference in (7).

Equilibrium employment in production L^D declines by 17.8%. This large decline mostly reflects the demographic reduction in the work force and the decline in individual labor supply. When the real interest rate is fixed to world markets, the capital labor ratio must remain constant in the long-run as well. Therefore, capital and output both decline in proportion with labor demand. Average disposable wage income $\bar{y}$ as defined in (6) falls by more than 40%. This large effect results mainly from the increase in taxes, the reduction in individual labor supply, the reduction in unemployment benefits due to partial indexation to net wages, and a smaller workforce. There is a further compositional effect resulting from the higher unemployment rate: a larger share of the workforce collects low unemployment benefits while a smaller part earns high net wages. Finally, the reduction in worker consumption per capita mostly reflects the large decline in disposable wage income. With earnings related pensions and fewer assets inherited from the active working period, consumption per pensioner declines by an amount not that much lower than consumption per worker.

Column AGE in Table 4 completes the aging scenario by also allowing for a long-run increase of the population by 6%. Demographic projections assume a higher fertility rate and a positive migration balance for Austria. Since the length of work and retirement periods are kept constant relative to column LIFE, the worker retiree ratio does not change. The population is simply scaled up in the long-run without any effect on the age structure. One finds that all tax rates, ratios and variables in per capita terms are exactly the same as in column LIFE. Only aggregate variables change. The increase in population partly offsets the decline of the workforce due to aging. Labor demand thus declines only by 13 as compared to 18% in column LIFE. With a constant capital labor ratio, the capital stock changes by exactly the same amount. The lower decline in average wage income similarly reflects the smaller reduction of the workforce.

4.3.2 Cutting the Replacement Rate

The pension reform experiments take the aging scenario as the new baseline. We compute percentage changes relative to the equilibrium in column AGE. The first scenario includes both (i) an elimination of the budget subsidy T^P to the pension system together with (ii) a reduction in the replacement rate. As to the first part, the PAYG system in Austria receives considerable transfers from the general budget and is, thus, not self-sustained. When these subsidies are entirely eliminated, one can obviously cut the wage tax to balance the general government budget while contributions must increase to sustain the PAYG system. Given that the implicit tax rate is much lower than the statutory contribution rate, one might have expected that replacing the wage tax by less distorting contribution rates alleviates the negative incentive effects on work and search effort. This is not so, however. The government budget position improves and allows for a 4.7 percentage point cut in the wage tax. The pension system, in contrast, requires an increase in the statutory contribution rate of exactly the same amount. Further, the *effective* social security tax rate also increases by exactly the same number of percentage points. Since the incentive effects hinge on the net wage, $\left(1 - t^W - \hat{t}^{SS}\right) w$, the offsetting changes in (effective) tax rates exactly cancel and remain without effect on the economy. Except for the adjustments in tax rates, the results are fully identical with those in column AGE and are thus not separately shown.

The replacement rate ties pensions of retirees to their previous working salaries, taken as an average over past net wage earnings. Column REPL reports the long-run effects when (i) the budget subsidy is eliminated and (ii) the replacement rate is cut from 0.78 to 0.7. With no further demographic adjustment, the retiree worker ratio is the same in both cases. The most obvious effect of cutting the replacement rate is the reduction of pension payments per capita which are down by approximately 5.5%. This is a considerable step towards financial viability of the pension system and allows for a 3 percentage point reduction of contribution rates. This relieve does not suffice to compensate for the rate increase necessitated by the elimination of the budget subsidy. Compared to the post aging state, the contribution rate increases on net by more than one percentage point to $.251 + .047 - .03 = 26.8\%$. The *effective* social security tax rate, in contrast, picks up by a full 3.6 percentage points since both the higher statutory rate and the lower replacement rate effectively reduce the rate of return and therefore inflate the tax component of any unit of contributions paid.

Table 4: Long-Run Macroeconomic Effects

	Variables	ISS	LIFE*	AGE*	REPL$^{\#}$	RET$^{\#}$
	ret.-worker ratio	0.454	0.552	0.552	0.552	0.446
t^{SS}	contribution rate	0.205	0.251	0.251	0.268	0.219
$\hat{t}^{SS}$	implicit s.s.tax	0.037	0.071	0.071	0.107	0.069
t^W	wage tax rate	0.205	0.353	0.353	0.258	0.135
r^P	replacement rate	0.781	0.781	0.781	0.703	0.703
θ	vacancy ratio	1.085	0.842	0.842	0.924	1.111
u	unempl. rate	5.800	7.908	7.908	7.058	5.510
K	capital stock		-17.879	-12.952	4.944	25.381
L^D	labor demand		-17.879	-12.952	4.944	25.381
w	gross wage		0.075	0.075	-0.025	-0.004
e	labor supply		-10.375	-10.375	4.007	13.788
ξ	search intensity		-18.980	-18.980	7.946	27.067
$\bar{y}$	average income		-43.299	-39.897	23.848	98.045
E	pension p.c.		-11.790	-11.790	-5.554	6.312
C^W	worker cons. p.c.		-37.297	-37.297	22.591	79.908
C^R	retiree cons. p.c.		-29.641	-29.641	18.295	66.354

ISS: Initial steady state, absolute values. LIFE: Life expectancy higher by 4.2 years, constant population. AGE: increased population due to immigration. REPL: reduction of pension replacement rate plus elimination of PAYG deficit T^P. RET: Increased retirement age. Upper half: absolute values; lower half: percentage changes. *) percentage change relative to ISS. #) percentage change relative to AGE.

Labor supply incentives hinge on the effective rather than the statutory social security tax rate. Since the total tax wedge $t^W + \hat{t}^{SS}$ falls by 5.9 percentage points relative to the aging scenario, workers supply more hours. Compared to column AGE, labor supply increases by 4%. Search incentives again respond more sensitively for the same reasons as discussed in the aging scenario. The lower labor tax burden made feasible by the cut in pension benefits directly boosts search incentives. In addition, when each employee works more hours, the job rent to the firm increases and induces her to hire more actively. By raising the matching probability of unemployed, a tighter labor market strengthens incentives for job search on top of the direct tax effects. The unemployment rate starts to fall. The fiscal budget is quite favorably affected when unemployment is lower and when other taxes generate more revenues (employment, capital and output increase by almost five percentage points). When the extra tax revenue is used to further cut the wage tax, the stimulus to labor supply and investment gets reinforced. This allows in equilibrium to cut the wage tax from 35 to 26%. The tax cut contributes to a lower unemployment rate which falls by almost one percentage point, from 7.9 to 7.06%.

4.3.3 Raising Retirement Age

A prominent reform proposal is to raise the retirement age. This measure does not change the overall size of the population but importantly affects its composition. The workforce expands and the number of retirees declines. Since effective retirement age is rather low in Austria, we consider in column RET a relatively large increase by three years. A larger part of overall life-time is spent working, and a smaller part is reserved for retirement. Consequently, the retiree worker ratio falls considerably, and is even slightly smaller than prior to aging. Essentially, the demographic effect of this scenario is aging in reverse, with very beneficial effects on the government budget and pension system.

Table 4 reports in column RET the combined, cumulative effects that obtain upon implementing all three measures. All wage related tax rates fall, both the wage tax as well as statutory and effective social security taxes. The wage tax rate falls by additional twelve percentage points relative to REPL, and is less than half the rate in the baseline AGE scenario. Consequently, work and search incentives markedly improve. The unemployment rate falls by 1.55 percentage points to a value as low as 5.5% which is a total reduction by 2.4 percentage points relative to the post aging baseline. Driven be aggregate labor supply, this scenario strongly expands the economy. Employment, capital and output increase by almost a quarter in the long-run, compared to the post aging equilibrium. Three factors drive the aggregate labor supply expansion. First, later retirement expands the workforce for purely demographic reasons. Second, the strong fiscal savings allow to cut the combined wage tax burden $t^W + \hat{t}^{SS}$ by more than 20 percentage points, down to 20.4% from 42.4% in the post aging baseline. Obviously, this huge policy shock strongly expands individual labor supply by 13.8%. Finally, with wage taxes effectively cut in half, the unemployed vigorously expand their job search which tightens up labor markets and boosts the outflow from unemployment. Consequently, the unemployment rate falls markedly and thereby again raises employment. Taking all three factors together adds up to a formidable job expansion which is frictionlessly accompanied by capital accumulation in a small open economy. The long-run increases in average disposable wage income and consumption per capita of workers and retirees are correspondingly large.

4.3.4 Sensitivity Analysis

Sensitivity analysis should trace out the range of potential results and should identify those parameters and behavioral margins that can importantly change the magnitude of the quantitative effects. Although the chosen parameters are well within the range of econometric estimates, they do vary quite substantially in the empirical literature. We have thus recomputed the long-run effects of our most comprehensive scenario to check sensitivity with respect to a few key parameters. Table 5 first repeats the stationary initial equilibrium prior to the aging shock (column ISS) and reports in column RET the cumulative effects of aging and pension reform. While the tax rates in the upper half of column RET in Table 5 are the same as in column RET of Table 4, the percentage changes are now expressed relative to the ISS rather than the post aging equilibrium as in Table 4, and are therefore much smaller since aging and pension reform offset each other to a considerable extent.

Given the emphasis on labor market effects, we first turn to the case of a more sensitive labor supply response. Comparing column σ_L with RET shows that the labor supply response very importantly determines the magnitude of the quantitative effects. When the elasticity is increased from .4 to .6, the effect on labor supply per capita more than doubles in equilibrium. We also find an important interaction with search effort which responds now much more vigorously, increasing by 6.6 rather than 2.9%, even though the search elasticity is kept the same. The effect is rather intuitive. With more hours worked, the value of a job must rise relative to the value of being unemployed. Unemployed agents must thus expect a bigger gain in locating a job which strongly boosts the incentives for job search. With higher search intensity, the unemployment rate falls more pronouncedly (to 5.2 instead of 5.5 percent) and aggregate employment expands more vigorously. It may be surprising at first sight that a higher search elasticity σ_S (from .4 to .6) influences the quantitative response to a much smaller extent. For any given return to job search, a higher elasticity will surely strengthen the search activity which expands by 4.1 instead of 2.9%. For this reason, the unemployment rate falls by more than in RET due to more intensive job search. In contrast to the case of a higher labor supply elasticity, the gains from accepting a job are not much affected. Therefore, this scenario holds only limited potential to magnify the overall macroeconomic response which is only slightly stronger.

The rule for unemployment benefits is $z = 0.5 \times b \times \left(1 - t^W - t^{SS}\right) w + 0.5 \times z^0$ in the base case where z^0 is the initial benefit level prior to the shock and b is the replacement rate for unemployment compensation. Column UB1 considers an alternative scenario where real unemployment benefits remain constant at $z = z^0$. The worker's outside option largely remains fixed in this case, so that wage taxes get fully shifted to employers and boost gross wages. Since the full pension reform allows a considerable *reduction* in the wage tax rate, falling from 20 to 13% roughly, the market wage increases less than in column RET. This strengthens job creation and aggregate employment, allowing for a smaller tax rate which suffices to stimulate labor supply and job search to some extent. The unemployment rate correspondingly falls somewhat more, from 5.8 to 5.3%, instead of 5.5% in column RET. The other extreme allows for full indexation of benefits to net wages as in column UB2, $z = b \times \left(1 - t^{W} - t^{SS}\right) w$. In this case, tax shifting is largely excluded. Consequently, employers benefit less from the wage tax reduction that is made possible by the reform. Full indexation thus retards job creation and employment but rather strengthens wage growth. The expansion is more moderate and the unemployment rate falls only to a minor extent.

Table 5: Sensitivity Analysis

Variables		ISS	RET	σ_L	σ_S	UB1	UB2	UB3
$\hat{t}^{SS}$	implicit s.s.tax	0.037	0.069	0.066	0.069	0.069	0.069	0.069
t^W	wage tax rate	0.205	0.135	0.113	0.134	0.132	0.139	0.134
u	unempl. rate	5.800	5.510	5.181	5.473	5.312	5.711	5.355
L^D	labor demand		9.142	12.433	9.253	9.444	8.827	9.300
w	gross wage		0.071	0.058	0.086	0.002	0.136	0.013
e	labor supply		1.983	4.706	2.034	2.112	1.847	2.013
ξ	search intensity		2.949	6.622	4.066	4.825	1.140	4.373

ISS: Steady state prior to aging. RET: Base Case Scenario, aging plus pension reform. σ_L: labor supply elasticity up from .4 to .6. σ_S: search elasticity up from .4 to .6. UB1: constant unemployment benefits. UB2: full indexation of unemployment benefits. UB3: replacement rate for unemployment benefits up from $b = .5$ to .7, bargaining power of firms down from $\phi = .5$ to .3. Upper half: absolute values. Lower half: percentage changes.

We finally investigate the quantitative effects of pension reform when a higher replacement rate for unemployment compensation is in place (see column UB3). To allow for a higher replacement rate, our calibration procedure also requires to reduce the bargaining power of firms ϕ in order to replicate the benchmark data. Compared to the base case value of one half, bargaining power of firms is reduced to $\phi = .3$ in the scenario of column UB3. Consequently, wage taxes get shifted to a larger extent which also works in the reverse direction, i.e. lower taxes lead to lower wages. For this reason, wage increase is now much less pronounced than in column RET, labor demand expands accordingly, and the unemployment rate falls by more than in column RET.

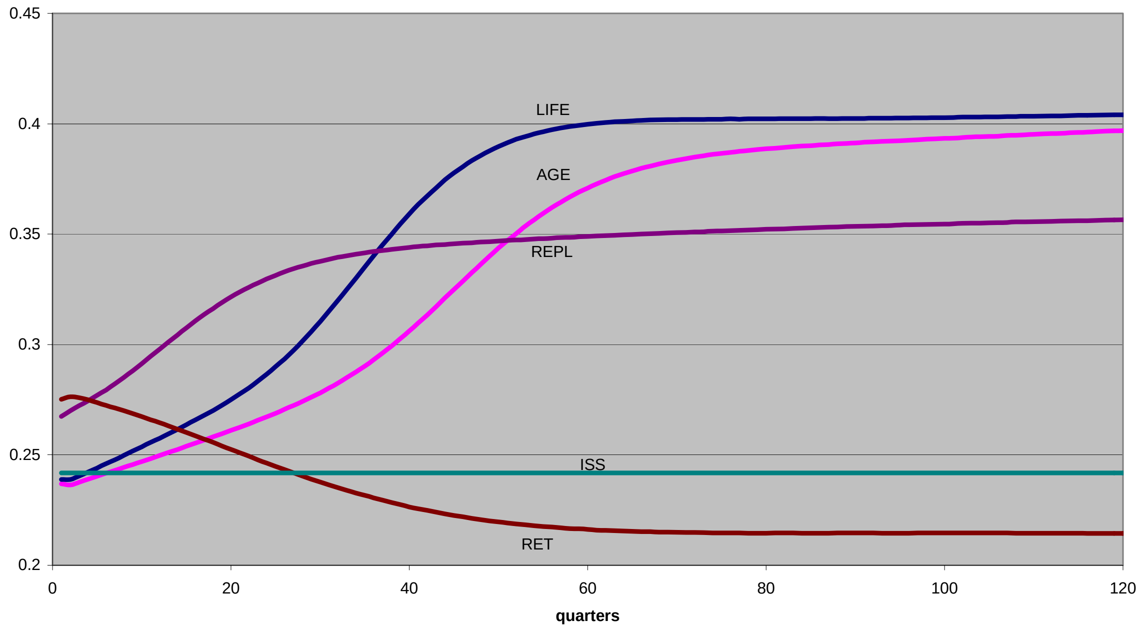
To sum up, the quantitative response to pension reform seems to be quite robust to changes of some important behavioral parameters. We find significant differences in labor supply and even more so in the search intensity. However, while the size of the long-run effects are sensitive to some key parameters of the model, such parameter variations are rather unlikely to change the qualitative nature of our results.

4.4 Transitional Effects

Figures 1-3 summarize the transitional dynamics for a few key labor market indicators: the tax distortion $t^W + \hat{t}^{SS}$, the unemployment rate u and aggregate labor supply $L = eN^E$.[11] The transitional solution reflects several dynamic forces. First, all variables must eventually move into the direction of the long-run changes as indicated in Table 4. Second, stock variables will usually start out from initial conditions and move monotonically towards long-run values. Third, however, stock variables may potentially evolve non-monotonically if some subsystems are governed by rather different adjustment speeds. In our model, for example, labor market dynamics is very fast, with a half life of only a few quarters. Investment takes much longer to adjust with a half life around seven years while demographic change is a truly slow process that takes several decades. Fourth, control variables such as hours worked or investment tend to jump instantaneously a big step towards the new steady state and subsequently change monotonously even though overshooting is possible in certain scenarios.

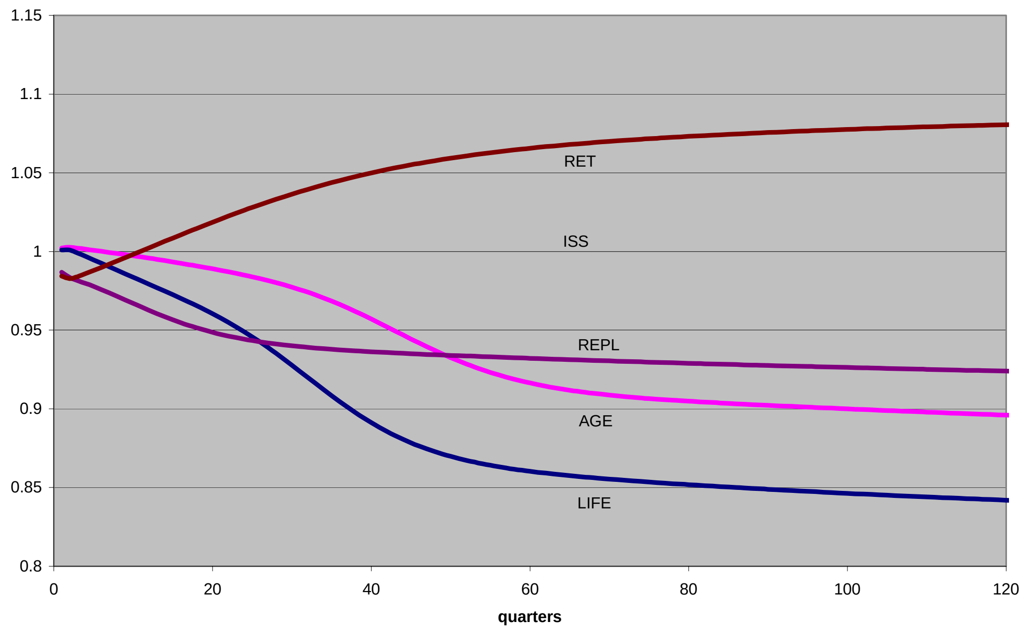
[11] Note that Table 4, instead, reports $L^D = L - \kappa v$, see (11).

Figure 1: Labor Tax Distortion



The aging scenarios are dominated by slow demographic change that keeps the economy for several decades in a transitional state. The scenario LIFE, for example, involves a once and for all decrease in the mortality rate such that the expected retirement period is prolonged. Given increased life expectancy, the retiree population starts growing slowly. Since LIFE assumes hypothetically that the population remains constant, the workforce must shrink as a consequence of an assumed decline in fertility which erodes the flow of newborns. This pattern is reflected in the trajectory LIFE of Figure 2. With a declining number of wage tax payers and social security contributors combined with a growing number of pensioners, the fiscal situation deteriorates slowly such that the labor tax distortion features an upward trend over a prolonged period of more than 60 quarters or 15 years. Subsequently, the tax burden stabilizes. Figure 1 shows that the labor supply distortion in the early adjustment period remains rather near the initial values prior to aging (line ISS) and grows only when the demographic change is felt more strongly. Accordingly, the detrimental labor supply effects of the higher tax burden are rather weak in the early adjustment period and get larger only later on when tax disincentives are more severe (see Table 4). Therefore, the aggregate labor supply (line LIFE in Figure 2) remains very close to the initial state in the first adjustment periods and starts to decline only after a while, with the individual labor supply response magnifying the effect of the demographic supply effect. On top of increased life expectancy, the scenario AGE additionally allows for an increase in population by 6% in the long-run which is phased in by assuming an accordingly larger inflow of newborns, reflecting somewhat higher fertility than in LIFE and a positive inflow of migrants. For this reason, aggregate labor supply in Figure 2 declines by less than in LIFE. Table 4 shows that the retiree worker ratio and therefore labor tax rates converge to the same long-run values. Accordingly, the labor tax distortion increases much more slowly in Figure 1 but eventually converges after a long adjustment period (not fully shown).

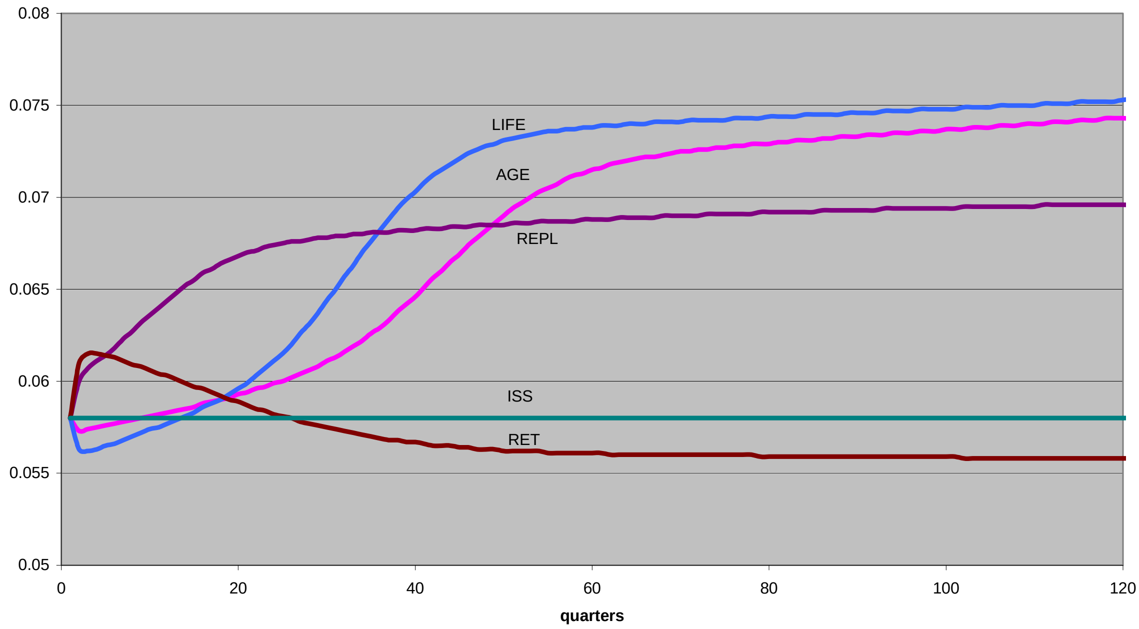
Figure 2: Aggregate Labor Supply



To understand the dynamic adjustments of the next scenarios REPL and RET, one must consider that they are implemented cumulatively so that RET includes REPL, see the discussion of Table 4. Therefore, we discuss first the short-run consequences of the scenario REPL, featuring an instantaneous and permanent reduction of the PAYG replacement rate. This being a relieve to the pension system, why is then the labor tax distortion jumping up instantaneously in Figure 1? In our model, the reduction in the replacement rate affects only *new* pensioners which makes the average per capita pension basically a predetermined stock variable. This implies that the lower replacement rate succeeds to reduce pension expenditures only very slowly since it takes a prolonged period until the inflow of new pensioners changes the average pension expenditure per capita of retirees. This limits the potential for cutting statutory tax rates in the early adjustment phase. On the other hand, the implicit social security tax $\hat{t}^{SS}$ jumps up immediately since today's workers must anticipate the less generous pension they will be offered in the future. This key anticipation effect results in an instantaneous upward jump in the labor tax distortion as shown in Figure 1.

Given that the lower replacement rate succeeds to squeeze pension expenditure only very slowly, the tax distortion remains larger than in the AGE scenario for quite some time, and falls below it only after more than a decade (about 50 quarters). Taking account of the disincentive effects of these higher effective tax rates, aggregate labor supply under this scenario is actually lower than in the post aging scenario for about the same time span (compare lines AGE and REPL in Figure 2). Since the next scenario RET raises retirement age on top of the reduction in the replacement rate, it similarly features an upward jump in the tax wedge. Subsequently, however, this scenario is much more effective and faster in reducing the tax distortion and therefore succeeds to expand aggregate labor supply much faster.

Figure 3: Unemployment Rate



We finally turn to unemployment dynamics which results both from demographic effects and tax incentives. In Figure 3, our demographic scenarios first lead to a decline in the unemployment rate while in the long-run, it is considerably higher than in the initial equilibrium. We have already argued that the slow but eventually large increases in tax rates ultimately lead to higher unemployment. In the short-run, however, the drop in fertility as part of the LIFE scenario reduces quite substantially the arrival of new workers and thus the inflow into unemployment. This demographic effect reduces the unemployment rate for a while but eventually the tax disincentives for work and search start to dominate, leading to a prolonged period of increasing unemployment rates. This initial demographic effect is less pronounced in the AGE scenario where the mass of labor market entrants is necessarily higher and the inflow into unemployment larger as compared to LIFE. In the subsequent phase, unemployment rates increase less dramatically because the tax distortion grows much more slowly as is evident from Figure 1.

When implementing a lower replacement rate in the post aging equilibrium (line RET in Figure 3), we have argued before that the effective labor tax wedge jumps up rather immediately as workers must anticipate less generous pensions and find that a larger share of their contributions amounts to being a tax. Since higher effective labor taxes discourage search effort on the part of unemployed, this scenario leads to an immediate increase in unemployment rates. Since the scenario RET includes a lower pension replacement rate, it leads to a short-run increase in unemployment rates for the same reasons. RET, however, additionally includes a postponed retirement age and therefore succeeds to reduce the structural unemployment rate in the long-run. This scenario therefore holds the potential for opposite short- and long-run effects on unemployment.

4.5 Generational Welfare

The preceding analysis has shown a rather impressive impact of demographic change and pension reform. It takes several decades, however, before the full effects are seen. Welfare effects should thus be large in the long-run but much more moderate in the short-run. Like public debt, pension reform importantly redistributes intergenerationally if there are no offsetting policy measures. Table 6 presents an intergenerational and aggregate welfare analysis. As in the scenarios REPL and RET in Table 4, we consider the reduction of the pension replacement rate and the mandated increase in retirement age. Table 6 presents the wealth equivalent changes in life-time utility per generation and in the aggregate, expressed in percent of life-time wealth. The Appendix explains the welfare measure. All changes are compared to the AGE scenario.

According to Table 4, reducing the pension replacement rate implies a higher implicit social security tax but allows for a much lower wage tax. The net effect is a rather pronounced reduction of the labor tax distortion in the long-run, leading to a significant expansion as well as a remarkable increase in disposable income and consumption. The preceding section showed, however, that the short- and medium-run effects are rather unfavorable. It takes time until the budget relieve allows for a reduction in the wage tax while the increase in the implicit social security tax is immediate. As a consequence, the labor tax distortion and unemployment first increase while labor supply is discouraged. The pattern of welfare changes in Table 6 is in line with these developments. The impact on current old generations is insignificant since the policy change relates only to new generations. Present working generations are the losers. Since a lower replacement rate cuts the private return on PAYG contributions, a larger part of the contributions represents effectively a tax. The pension rule simply becomes less favorable. On the other hand, current workers are unable to share in the benefits of improved labor market conditions and growth since it takes too long before the wage tax cuts and the improvements in the labor market take effect. A currently newborn working generation thus suffers a welfare loss equivalent to 4.4 percent of her life-time wealth.

Table 6: Welfare Effects of Pension Reform

	Old Generations			New Generations		Aggregate
Scenario*	Retired	Workers	All old	Current	Future	Welfare Change
REPL	-0.164	-4.468	-3.169	-4.400	9.038	-2.926
RET	0.427	5.316	3.840	7.278	37.635	26.662
RETALL	0.238	1.043	0.800	3.070	40.168	22.438

*)Welfare change in percent of life-time resources. RET considers the increase in retirement age in isolation while RETALL gives the cumulative effect of both scenarios and compares to column RET in Table 4.

The winners are future generations. Only after several decades do new generations find better conditions than they would have if the economy evolved along the initial AGE equilibrium in the absence of the policy shock. In the very long-run, future generations eventually gain quite impressively by an amount equivalent to 9 percent of life-time wealth. The reduction in the replacement rate clearly redistributes from present to future working generations. What is the net effect? The last column of Table 6 reveals a significant aggregate welfare loss of about 2.7 percent averaged over all present and future generations (see the Appendix for the definition of this measure). This negative effect reflects the fact that the welfare gains are concentrated only among new generations in the distant future while all present as well as new generations over the next three decades loose significantly.

The next line in Table 6 reports the welfare effects of an increase in the average retirement age by three years, without changing the pension replacement rate. Already Table 4 reveals that the effects are several magnitudes larger. Despite of a constant overall population, the scenario reduces the retiree worker ratio from .55 to .45 in the long-run which results in a strong increase of aggregate labor supply. The vigorous output expansion and the reduction in unemployment allow for sustainable government finances with much lower wage taxes. The overall labor tax distortion falls by a full 15 percent. These adjustments almost result in a doubling of disposable average wage income in the very long-run. Consumption expands accordingly. Since the demographic labor supply effect occurs only very slowly, Table 6 reports large welfare gains for new generations born in the distant future while the gains to current generations are much more moderate. Again, retired generations are largely unaffected while existing workers gain by about 5.3 percent of life-time wealth, on average. The welfare gain of the presently new born generation amounts to 7.3 percent of life-time resources, and increases continuously for all new generations entering at a later date until the full benefits are obtained for future generations born into the new steady state. Interestingly, all age groups on average would gain from this scenario although the gains are concentrated among future generations. The last line in Table 6 runs both scenarios cumulatively as in the last column of Table 4. The results are understood by the first two lines. With such large shocks, some non-linearity is expected so that the two lines do not add up precisely to give the third line.

5 Conclusions

Aging of the population has rendered the unfunded pension system unsustainable in its current form and requires some larger policy initiatives for reform. The demographic labor supply effects of aging and the upward pressure on labor taxes should importantly affect labor market performance. This paper has presented a computable equilibrium model of the Austrian economy. The model captures the essential aspects of the Austrian pension system including a tax benefit linkage and a calculation of the implicit tax component of social security contributions. It also contains a particularly detailed structure of the labor market that explains the equilibrium structural unemployment rate as a balance between the incentives of firms to create jobs and hire new workers and the incentives of unemployed workers to search for jobs. Hours worked are also endogenously determined and affect job rents and firms' incentives to create new jobs.

Applying this framework to aging and pension reform scenarios, we record several important results. First, aging can profoundly influence long-run structural unemployment because it puts pressure on the fiscal system and thereby contributes to a secular increase in the labor tax burden. Second, labor market effects of pension reform can be quite pronounced as well, not only via the classical mechanism of endogenous labor supply, but also via its effect on the incentives for job creation by firms and job search by unemployed workers. This can easily involve 2 to 3 percentage points of the long-run unemployment rate. Third, the intertemporal effects of pension reform may result in opposite short- and long-run adjustment of the unemployment rate. Fourth, the increase in retirement age by about three years is a potent strategy to restore sustainability of the pension system and can reverse a large part of the aging effects. Fifth, in the absence of an explicit debt policy to control for intergenerational redistribution, the gains from pension reform are mostly to the benefit of future generations. Being limited to new generations only, the increase in retirement age has the potential to benefit all generations, present and future.

Further work should address a number of issues. The modeling of the pension system should be extended to allow for alternative institutional arrangements as well. Interesting and also urgent policy scenarios include the introduction of individual accounts within the current PAYG system that might help to strengthen the tax benefit linkage and to reduce the individual tax component of contributions. After introducing individual accounts, one should investigate the economic consequences of a partial move to a funded system. All these issues are more or less intensively discussed in Austria and elsewhere (see, for example, the contributions in Holzmann and Stiglitz, 2001). It should be possible to extend the current framework to capture these issues. Given the large model responses to demographic change, future work should also consider the sensitivity of existing population projections which seem to allow for a range of developments and are sensitive with regard to the assumed mortality, fertility and migration rates. Finally, pension reform in other large economies with similar demographic developments may have significant effects on worldwide savings and international capital markets. It would be thus important to allow for an interest rate response from international capital markets in our small open economy model.

Appendix: Welfare Calculus

Table 6 reports generational welfare changes. It can be shown that indirect utility in (2-3) is proportional to life-time wealth $\mathcal{W}$,

$$\begin{aligned} V_{v,t}^{W} &= \mathcal{W}_{v,t}^{W} \cdot P_t^W, \quad P_t^W \equiv \pi_t^{\frac{1}{1-\sigma}} / \left(1 + t^C\right), \\ V_{v,t}^{R} &= \mathcal{W}_{v,t}^{R} \cdot P_t^R, \quad P_t^R \equiv \left(\varepsilon_t \pi_t\right)^{\frac{1}{1-\sigma}} / \left(1 + t^C\right). \end{aligned} \tag{A.1}$$

Inverting indirect utility yields the life-time expenditure function $\varrho\left(V_{v,t}^W, P_t^W\right) = V_{v,t}^W / P_t^W$. We now index values referring to initial and new equilibria by an upper index, e.g. P_t^{W0} and P_t^{W1}. Taking initial prices as a reference, the equivalent variation EV gives the wealth equivalent change in welfare. It is defined (separately for each generation) as

$$EV_{v,t}^{W} = \varrho\left(V_{v,t}^{W,1}, P_t^{W0}\right) - \mathcal{W}_{v,t}^{W0} = V_{v,t}^{W,1} / P_t^{W0} - \mathcal{W}_{v,t}^{W0}. \tag{A.2}$$

This per capita measure is easily aggregated. Table 6 reports the aggregate equivalent variations per capita, and in percent of life-time wealth, for various generations in the following order: $100 \times EV_1^R / \mathcal{W}_1^R$, $100 \times EV_1^W / \mathcal{W}_1^W$, $100 \times EV_1^O / \mathcal{W}_1^O$, where $EV_1^O \equiv EV_1^W + EV_1^R$ and $\mathcal{W}_1^O \equiv \mathcal{W}_1^W + \mathcal{W}_1^R$, where the policy shocks occur in period $t = 1$. Next, the welfare changes of present and future new generations are shown, $100 \times EV_{1,1}^W / \mathcal{W}_{1,1}^W$ and $100 \times EV_{T,T}^W / \mathcal{W}_{T,T}^W$. The last entry of Table 6 reports an aggregate welfare measure,

$100 \times \left(EV_1^O + EV_1^N\right) / \left(\mathcal{W}_1^O + \mathcal{W}_1^N\right)$, where

$$\begin{aligned} EV_1^N &= \sum_{t=2}^{T} N_{t,t}^W EV_{t,t}^W \cdot \prod_{u=2}^{t} \tfrac{1}{1+r_u} + N_{T,T}^W EV_{T,T}^W \tfrac{1+r}{r} \cdot \prod_{u=2}^{T} \tfrac{1}{1+r_u}, \\ \mathcal{W}_1^N &= \sum_{t=2}^{T} N_{t,t}^W \mathcal{W}_{t,t}^W \cdot \prod_{u=2}^{t} \tfrac{1}{1+r_u} + N_{T,T}^W \mathcal{W}_{T,T}^W \tfrac{1+r}{r} \cdot \prod_{u=2}^{T} \tfrac{1}{1+r_u}. \end{aligned} \tag{A.3}$$

Since EV_{tt}^W is per capita, it must be multiplied by the size of the new cohort (while EV_1^W is already an aggregate of all present worker generations) and is discounted back to period 1 to compare with present old generations. In our computations, a new steady state is attained in some finite period T. The second term is the welfare change from period $T+1$ to infinity, derived from comparing the new with the initial steady state equilibrium.

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